NIOSH HEALTH HAZARD EVALUATION:

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Transportation Security Administration

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Airport X-ray Study Framework

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DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

Summary

What is NIOSH doing?

- The Transportation Security Administration requested that National Institute for Occupational Safety and Health (NIOSH) conduct an independent study to determine the potential radiation exposures to employees who operate X-ray generating machines. NIOSH researchers will also assess the work place practices, training information, and equipment and maintenance requirements. NIOSH will use its findings to make recommendations regarding the need for radiation badges.

How long will the study take?

- About two years. Why? Because several hundred TSA employees will be monitored and the areas around the equipment will be monitored for at least six months up to a full year.

How were the airports selected for this study?

- The airports included in this study were identified during the NIOSH Opening Conference (May 21, 2003). NIOSH researchers lead a brainstorming session that identified 30 airports as potential candidate airports for this study. The number was reduced to 12 after considering (1) baggage volume, (2) number and variety of X-ray generating machines, (3) seasonal travel patterns, (4) number of TSA employees operating X-ray generating machines, (5) work practices (rotation and work shifts), (6) type of airport (originating vs. connecting), (7) prior employee complaints, and (8) geographic location.

What Airports are included in this study?

- Twelve airports selected for this study are listed below, along with the airport category (size) and the type of activities that will be conducted by NIOSH:

Airport	Category*	Characterize Work Practices	Radiation Monitoring**
Baltimore	X	Yes	Yes
Boston	X	Yes	Yes
Chicago	X	Yes	No
Cincinnati	I	Yes	Yes
Harrisburg	II	Yes	No
Honolulu	X	Yes	No
Las Vegas	I	Yes	No
Los Angeles	X	Yes	Yes
Miami	X	Yes	No
Philadelphia	X	Yes	No
Providence	I	Yes	Yes
West Palm Beach	I	Yes	Yes

* TSA Airport Categories X, I, II, III, IV represent the largest (X) to the smallest (IV) airport size by volume of passengers.

**Airports with no radiation monitoring will have their work practices compared to similarly sized airports with radiation monitoring data to decide if additional radiation monitoring is warranted.

Introduction

The National Institute for Occupational Safety and Health (NIOSH) received three Health Hazard Evaluation (HHE) requests from Transportation Security Administration (TSA) employees between November 2002 and March 2003 (Table 1). The requestors expressed concerns about a variety of potential exposures including diesel exhaust, dirt, dust, hazardous items found in baggage, and X-rays. The concerns, other than X-rays, were addressed separately by NIOSH researchers. A concern common to all three requests was exposure to X-rays from passenger and checked baggage screening machines. On March 26, 2003, TSA Management submitted a separate request for NIOSH *"to perform an independent study to determine the levels of radiation emissions from the various TSA screening equipment."*

Table 1. Employee HHE Requests regarding X-ray exposures from airport screening machines

Date	Airport
11/15/2002	Cincinnati (CVG)
2/28/2003	Honolulu (HNL)
3/19/2003	Baltimore (BWI)

In response to the requests, NIOSH is conducting a health hazard evaluation using the framework described in this document. On May 21, 2003, NIOSH researchers conducted an opening conference with TSA management and screener representatives at the TSA head quarters in Arlington, Virginia to assist in developing the study framework. The purpose of the opening conference was to meet with screener representatives, provide an overview of the radiation study objectives, and obtain TSA Screeners' input to the study to ensure their radiation safety concerns are addressed. Upon completion of data collection, NIOSH will assemble and analyze the data and will prepare a written report of its findings, conclusions, and recommendations. A list of the management and screener representatives is provided in Appendix A.

NIOSH will enter into an Interagency Agreement (IA) with TSA for the costs associated with dosimetry, travel, instrumentation, and database development as needed. This assistance is necessary because the study size, duration, and scope are beyond the typical HHE encountered by NIOSH. TSA will pre-review the draft report **for security and classified information issues only**, then all parties will receive the results of this study at the same time.

Objectives

The three objectives of the NIOSH study are:

1. Assess the work practices, procedures, and training provided to TSA employees who operate machines that generate X-rays;
2. characterize the radiation exposure among employees who operate these machines; and
3. determine if TSA employees who operate these machines are exposed at sufficient levels to require routine monitoring with radiation dosimeters.

Background

FAA Cabinet X-ray Systems 1975 - 2001

In 1975 the Federal Aviation Administration (FAA) adopted rules regarding the use of cabinet X-ray systems to screen carry-on baggage. At that time, the use of X-ray systems for this purpose was relatively new, and the FAA took a number of steps to evaluate the safety and environmental impact of these systems. FAA rules required that employees operating the systems to be monitored for potential radiation exposures.

> One reason X-ray exposures have become an employee concern is a recent FAA ruling to remove the requirement for monitoring workers with radiation dosimeters (July 17, 2001) [66 Fed. Reg. 37330 (2001)].

Figure 1: InVision CTX 2500

Since 1975, the number of X-ray screening machines increased as the detection capability improved. One of the most significant equipment improvements over the past 25 years has been the introduction of computed tomography (CT) machines to detect explosive materials in passenger and checked baggage (Figure 1). In 1990, the Aviation Security Improvement Act required the FAA to establish criteria for certification of explosive detection systems (EDS), to develop protocols for testing them, and to have an independent means of testing them for certification (FAA, 1995). In 1994, the FAA approved the use of CT as the first certified explosive detection device and began installing these X-ray screening machines in the fall of 1995 (FAA, 1996). In addition, the White House Commission on Aviation Safety and Security recommended that checked baggage for domestic flights be screened and provided funding for checked baggage screening equipment. In 1996, the FAA established the Security Equipment Integrated Product Team (SEIPT) whose mission was to identify, test, select, and deploy advanced technology security systems to improve domestic aviation security (FAA, 1997).

Creation of TSA

The September 11, 2001, terrorist attacks involving four U.S. commercial aircraft that resulted in the loss of human life at the World Trade Center, the Pentagon, and in southwest Pennsylvania, demonstrated the need for increased air transportation security. On November 19, 2001, Congress enacted the Aviation and Transportation Security Act (ATSA) [49 CFR[1] Parts 1500 et al.]. Under ATSA, the responsibility for inspecting persons and property carried by aircraft operators and foreign air carriers was transferred to a newly formed agency, the Transportation Security Administration (TSA). This rulemaking transferred the FAA rules governing civil aviation security to TSA.

> **<u>Changes affecting Screeners</u>**
> 1. Additional qualifications, training, and testing
> 2. A requirement that all checked baggage is inspected for explosives and incendiaries before loading.

[1] *Code Federal Regulations.* See CFR in references.

Reasons for Radiation Monitoring

In 1975, the FAA rules included a requirement that operators of the X-ray generating equipment wear radiation badges, even though radiation experts who submitted comments did not find it necessary. In 1997, the FAA omitted the requirement that aircarriers monitor their employees for radiation exposure (August 1, 1997) [62 Fed. Reg. 41739 (1997)]. The FAA justified this decision based on the fact that they had not been aware of any incident in which a person received excessive radiation from X-ray machines used for screening. Due to that safety record and "encouraged by today's technology," the final rule eliminated the need for dosimeters. Despite this ruling, there are many reasons for using radiation badges which include:

1. ***assessing the exposure to individuals and to groups, primarily for radiation protection purposes,***
2. ***documenting exposures or the lack thereof for regulatory or legal purposes,***
3. ***detecting unsafe working practices,***
4. ***detecting changes in exposure conditions (including accidental exposures),***
5. aiding the administration of ALARA (As Low As Reasonably Achievable),
6. ***satisfying union or employee concerns,***
7. helping to satisfy society in general that radiation industries are concerned about the doses people receive,
8. ***verifying the effectiveness of engineering and process controls in containing radioactive material and reducing radiation exposure.***

[NOTE: The items listed in ***bold italitcs*** are the primary drivers for this study. Reasons 1 through 7 are provided in NCRP Report 101.]

Other Positions Regarding Radiation Monitoring

The International Air Transportation Association (IATA) Dangerous Goods Regulations publish procedures for safe transport of articles and substances with hazardous properties. These regulations state that no radiation monitoring is needed if employee doses are below 100 mrem (millirem) in a year. IATA regulations require a dose assessment program via work place monitoring or individual monitoring for doses likely between 100 and 600 mrem in a year, and require individual monitoring for doses likely to exceed 600 mrem in a year (IATA, 2003).

The Department of Energy (DOE) requires that radiation monitoring be conducted on workers who, under typical conditions, are likely to receive an effective dose of 100 mrem or more per year, or if a declared pregnant female could receive 50 mrem or more during the period of pregnacy (10 CFR 835.402).

The Nuclear Regulatory Commission (NRC) requires that radiation monitoring be conducted on workers who are likely to receive 500 mrem or more per year, or if a declared pregnant female could receive 100 mrem or more during the entire pregnancy (10 CRF 20.1502).

The Occupational Safety and Health Administration (OSHA) requires that radiation monitoring be conducted on workers who enter a "restricted area under such circumstances that he receives, or is likely to receive, a dose in any calendar quarter in excess of 25 percent of the applicable dose limit" (29 CFR 1910.1096). The work area for TSA employees is not considered to be "restricted" according to the OSHA definition since a restricted area is any area controlled by the employer for purposes of protecting individuals from exposure to radiation or radioactive materials. The OSHA regulations do not specify monitoring requirements for unrestricted areas.

Dose Limits

The occupational and public dose limits by various government and scientific organizations are listed in Table 2. In 1999, the FAA adopted the radiation exposure limits from the 1998 American Conference of Government Industrial Hygienists (ACGIH) TLVs® and BEIs® booklet in lieu of outdated OSHA standards.[2] These limits were based on the guidance of the International Commission on Radiological Protection (ICRP). The TSA workforce also falls under OSHA regulations but TSA has not officially adopted ACGIH radiation exposure limits and are subject to the outdated OSHA standards. Further, the OSHA radiation standards apply to only employees working in a "restricted" area, which do not apply to TSA workers since they do not work in "restricted" area as defined by the standard. NIOSH researchers will work with TSA, OSHA, and other federal agencies to resolve this discrepancy. Once this issue is resolved and the data collection effort is completed, NIOSH researchers will be able to make recommendations associated with radiation monitoring for TSA employees.

[2] OSHA Website: http://www.osha.gov/SLTC/radiationionizing/index.html.

Table 2. Occupational and Public Dose Limits					
Dose Limits	**DOE**	**NRC**	**OSHA[1]**	**NCRP (1993)[2,3]**	**ICRP (1991)[2]**
Occupational	**5000 mrem per year**	**5000 mrem per year**	**1,250 mrem per quarter** for the whole body (head and trunk; active blood-forming organs or gonads)	**5000 mrem per year**	**5000 mrem per year**
Lens of eye	**15,000 mrem per year**	**15,000 mrem per year**	**1,250 mrem per quarter**	**15,000 mrem per year**	**15,000 mrem per year**
Hands and Forearms; feet and ankles	**50,000 mrem per year**	**50,000 mrem per year**	**18,750 mrem per quarter**	**50,000 mrem per year**	**50,000 mrem per year**
Skin	**50,000 mrem per year**	**50,000 mrem per year**	**7,500 mrem per quarter**	**50,000 mrem per year**	**50,000 mrem per year**
Cumulative	None	None	**5,000(N-18) mrem** N=age (y)	**1000 mrem x age (y)**	**10,000 mrem in 5 y**
Public	**100 mrem** per year for members of the public entering a controlled area	**100 mrem** per year from a licensed operation; *or* **2 mrem** per hour from any unrestricted area	None	**100 mrem** for continuous exposure *and* **500 mrem** for infrequent exposure	**100 mrem** and, if needed, higher values provided that the annual avg over 5 y does not exceed **1000 mrem**
Embryo-fetus	**500 mrem** for the period from conception to birth of a declared pregnant worker	**500 mrem** for the period from conception to birth of a declared pregnant worker	None	**50 mrem** per month once pregnancy is known	**200 mrem** to the woman's abdomen once pregnancy has been declared
Lens of eye, skin, and extremities	None	None	None	**5000 mrem**	**1500 mrem** to lens of eye *and* **5000 mrem** to skins, hands, and feet.
Neglible Individual Dose (annual)	None	None	None	**1 mrem**	None

1. OSHA dose limits are applicable only to individuals who work in a restricted area. Restricted area means any area which is controlled by the employer for purposes of protection of individuals from exposure to radiation or radioactive materials.
2. NCRP and ICRP occupational and public dose limits are annual effect dose limits (E); the cumulative dose limit is a cumulative effective dose limit. The effective dose (E=wRHT) is intended to provide a means for handling nonuniform irradiation situations. The tissue weighting factor (wT) takes into account the relative detriment to each organ and tissue including the different mortality and morbidity risks from cancer. In other words, the risks for all stochastic effects will be the same whether the whole body is irradiate uniformly or not.
3. NCRP embryo-fetus dose limit is an equivalent dose (HT) limit in a month once pregnancy is known. The equivalent dose limit is based on an average absorbed dose in the tissue or organ (DT) and weighted by the radiation weighting factor (wR) for radiation impinging on the body (HT= wR DT). NCRP lens of eye, skin, and extremity dose limit is an annual equivalent dose limit.

Methods

NIOSH researchers will conduct a basic characterization of TSA employees' exposure potential to X-rays at 12 airports. In addition, at 6 of the 12 airports, an exposure assessment using radiation dosimeters will be performed. This work will focus on those employees that operate EDS machines because these machines produce higher levels of radiation than the X-ray scanning machines.

Airport Selection

The airports included in this study were identified during the NIOSH Opening Conference (May 21, 2003). NIOSH researchers distributed copies of the "Opening Conference; Briefing of Study Objectives" which contained the first 6 airport selection criteria listed below. The purpose of the selection criteria was to make the airport selection process as scientific as possible but there was also a need to address the concerns of TSA management and screener representatives. As a result, 2 additional selection criteria (prior employee complaints and geographic distribution) were added to the list.

Airport Selection Criteria

1. Baggage and passenger volume based on TSA Airport Category designations.
2. EDS Machine Type (set-up, location, and variety of screening equipment including integrated and non-integrated systems)
3. Time of Year (seasonal travel patterns)
4. Number of TSA employees operating the EDS machines
5. Work Practices (consistency)
    a. Rotation
    b. Shift work
    c. Job Titles
    d. Cross-training
6. Airport Type (originating, international, or connecting airport).
7. Prior employee complaints
8. Geographic location

NIOSH researchers lead a brainstorming session that identified 30 airports as potential candidate airports for this study (Table 4). The number was reduced to 12 after applying the airport selection criteria. All of the selected airports will receive a basic characterization and seven were initially chosen for radiation monitoring (Table 5).

Table 4. Number of airports by category, discussed, and selected for study

Category and relative size	# of airports	# of airports initially discussed	# of airports selected	Comments
X (largest)	21	13	7	Large number of EDS machines and employees
I	61	9	4	
II (medium)	50	3	1	
III	127	2	0	No EDS machines
IV (smallest)	195	3	0	
TOTAL	**454**	**30**	**12**	

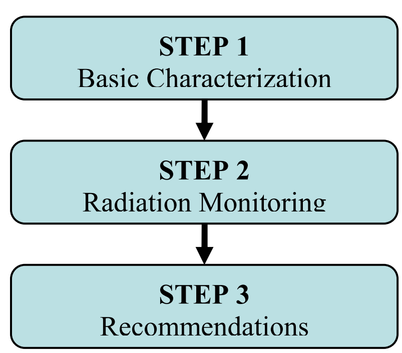
Table 5. Airports included in the X-ray Study

Basic Characterization and Radiation Monitoring*	Basic Characterization Only
BWI Baltimore- Washington Int'l, Cat X	**ORD** Chicago O'Hare Int'l, Cat X
BOS Boston – Logan Int'l, Cat X	**MDT** Harrisburg Int'l, Cat II
CVG Cincinnati/Northern Kentucky Int'l, Cat I	**HNL** Honolulu Int'l, Cat X
LAX Los Angeles Int'l, Cat X	**LAS** Las Vegas – McCarren Int'l, Cat I
PVD Providence – T.F. Green Municipal, Cat I	**MIA** Miami Int'l, Cat X
PBI West Palm Beach Int'l, Cat I	**PHL** Philadelphia Int'l Cat, X

* Airports selected for radiation monitoring may change if justified by the data from the Basic Characterization effort.

Based on the data gathered from the basic characterization, NIOSH researchers will determine whether a change is justified to the initial list of airport selected for radiation monitoring. If a change is justified, then NIOSH will work with TSA management and screener representatives to resolve any concerns.

Basic Characterization



This will be conducted at all 12 airports selected for this study *before* exposure assessment is started. During this activity, discussions will be held with workers, TSA management at headquarters and individual airports, equipment manufacturers, and other federal and state government officials. The purpose of these discussions will be to gain a better understanding of the tasks, work practices, processes, exposure controls, maintenance, training, and state controlled programs associated with the X-ray generating machines. In addition, walkthrough surveys will be conducted at all the airports included in this study to review airport operations, tasks, use of personal protective equipment, and engineering controls associated with the X-ray generating equipment.

As part of this process, a review will be conducted of maintenance records (past 2 years) and standard operating procedures regarding the X-ray generating machines. Video imaging and digital photographs will also be taken, but will remain confidential until reviewed and released by the appropriate TSA authority.

Radiation Monitoring

After all the airport basic characterizations are completed, radiation monitoring will be performed at 6 of the 12 airports included in this study. The primary goal is to assess the exposures to X-rays from the various EDS and screening machines. The challenge is to do this accurately and efficiently, regardless of the diversity of exposures across workers, airports, and time. For the airports selected in this study, radiation measurements will be obtained in a variety of locations and on employees who volunteer to wear radiation badges during a ***monitoring period ranging from six months to a year***.

Who will be selected for radiation monitoring?
Screeners that operate EDS machines will receive priority for radiation monitoring, because:

1. these machines have a higher radiation output than the carry-on screening machines;
2. there is limited amount of dosimetry data on their potential exposures; and
3. these machines were recently (within the past 5 years) installed in mass throughout U.S. airports.

Screeners that operate other X-ray generating equipment will be selected for radiation monitoring based on their work practices at the airport.

Will all employees receive radiation badges?
No. The number of employees that receive radiation badges at a selected airport will be determined by the size of the airport, work practices, types of X-ray generating machines, and number of volunteers willing to participate in this study.

Who will control the dosimetry results?
NIOSH will control the exposure data during the study and will provide copies of the results to TSA management after the study is complete.

How will the employees be notified of their dosimetry results?
NIOSH will provide a letter that summarizes their dose (if any), an explanation of the results, and where they can learn more about radiation. This letter will be sent after the NIOSH study is completed. However, an employee may be contacted by phone for quality assurance purposes. For example, to ensure that their work practices remained constant over the monitoring period, or to investigate any unexpected dose results.

Can the number of employees or airports that receive radiation monitoring change?
Yes, but only after consultation with TSA management and screener representatives. The number of employees who receive radiation badges could change due to preliminary results. The goal is characterize the potential exposures to these workers and if preliminary data suggests a large variability among workers, then more data would improve our ability to properly interpret the results.

What type of radiation measures will be performed?
The types of radiation measurements will include:

1. FDA field test survey to ensure X-ray generating machine is within FDA compliance,
2. Personal whole body dosimeter,
3. Personal extremity dosimeter.
4. Area dosimeters (attached to various X-ray generating machines)
5. Real-time radiation measurements at employee locations

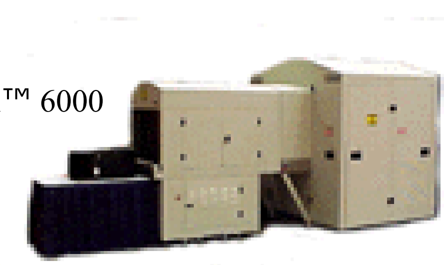
Figure 2. Landauer extremity (ring) and whole body dosimeters.

Type of machines included in study

The types of machines that will be included in this study are categorized as (1) Explosive Detection Systems (EDS), (2) Threat Image Protection Ready X-ray (TRX), and (3) Explosives Trace Detectors (ETD). The manufacturer and equipment models are provided in Table 3.

Table 3. Types of Machines included in the study(type of radiation source)		
EDS (X-rays)	**TRX (X-rays)**	**ETD (may contain Ni-63)**
InVision CTX-2500	Heimann 6040I	Barringer Ionscan 400 & 400B
InVision CTX-5500	Heimann 7555I	Iontrack Itemiser (DOS & Windows)
InVision CTX-9000	Rapiscan 520B	ThermoDetection Egis I
L3 3DX 6000	Rapiscan 522B	ThermoDetection Egis II
	PerkinElmer Linescan 110	
	PerkinElmer Linescan 208	
	PerkinElmer Linescan 237	

L3 3DX™ 6000



Timeline

This study is expected to be completed ***within two years*** following approval of the study framework. The logistics associated with travel to each airport and/or the number of employees that will be included in the radiation monitoring will be addressed as the study progresses. These details will be shared with the NIOSH HHE Contacts (Appendix A) as the details are finalized among the NIOSH researchers, TSA management, screener representatives, Airport Security Directors, and other participating federal agencies.

The Greater Cincinnati/Northern Kentucky International Airport will be the first airport visited for this study. The Cincinnati airport was chosen due to its close proximity to the NIOSH office, and it will serve as a pilot study for the remaining airports. The information collected from this initial study effort will help determine the training requirements, equipment requirements, scheduling, and required TSA operational data for future airport visits.

Definitions

Cabinet X-ray Systems: A cabinet X-ray system is an X-ray system installed in an enclosure. The enclosure is intended to protect people from the X-rays generated and to exclude people from the enclosure's interior. Cabinet X-ray systems are primarily used for security screening and industrial quality control. Security applications range from screening baggage at an airport to examining whole trucks at the border. Industrial quality control applications include the X-ray examination of foods, circuit boards, and tires. Some cabinet X-ray systems are also medical devices, such as a cabinet X-ray system used for analysis of tissue samples in a medical laboratory.

Computed Tomography (CT) is a procedure that uses special X-ray equipment to obtain cross-sectional pictures of areas inside baggage. A computer then assembles these pictures into detailed images of contents.

Electron: A subatomic particle with a negative charge. The electron circles the nucleus of an atom.

Ionizing Radiation: Radition that has enough energy to remove electrons from substances that it passes through, forming ions.

Radiation Dosimeter: a small portable instrument (such as a film badge, thermoluminescent, or pocket dosimeter) for measuring and recording the total accumulated personal dose of ionizing radiation.

rem: A unit of radiation dose; an estimate of the health risk that exposure to radiation could have on human tissue.

mrem (millirem): A unit of radiation dose equal to one-thousandth of a rem.

X-rays: X-rays are high-energy photons produced by the interaction of charged particles with matter. X-rays and gamma rays have essentially the same properties, but differ in origin; i.e., X-rays are emitted from processes outside the nucleus, while gamma rays originate inside the nucleus. They are generally lower in energy and therefore less penetrating than gamma rays. Literally thousands of X-ray machines are used daily in medicine and industry for examinations, inspections, and process controls. X-rays are also used for cancer therapy to destroy malignant cells. Because of their many uses, X-rays are the single largest source of manmade radiation exposure. A few millimeters of lead can stop medical X-rays.

Appendix A

Organization	Name	Title	Phone Number	E-mail
HHE Contacts				
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	Edward Fisher	BOS Screener	(978) 430-9301	Meagan481@msn.com
	Michael McCoucha	CVG Screener	(513) 481-0639	Macmccoucha@aol.com
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	Shelby Weitz	PBI Screener	(561) 997-5829	Shelbydanna@aol.com

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